MOKELUMNE WATERSHED AVOIDED COST ANALYSIS:

Why Sierra Fuel Treatments Make Economic Sense

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Appendix J: Preliminary Assumptions

J.1 Overview

This section provides a preliminary outline of a biophysical pathway and the economic costs associated with the Mokelumne Avoided Cost Study. Steps in the biophysical pathway, as analyzed in the study, are listed numerically and seek to encompass forest stand conditions, fuel and vegetation management treatments, wildfire severity, erosion of sediment into water storage and conveyance facilities, bark beetle-caused tree mortality, and economic costs. There are numerous assumptions and hypotheses that fall under each step of the biophysical pathway, which we attempt to capture here.

This analysis does not cover some related biophysical processes and economic activities, such as:

- Impacts upon bird, fish and wildlife habitat.
- Impacts upon forest cover, snowpack accumulation and duration, and the timing of water delivery.
- Public recreation activity and impact upon campgrounds, signage, trails, patterns of use, and associated local economic activity.
- Smoke, air pollution, air quality, and impact upon people's respiratory health.
- Impacts upon cultural resources.

J.2 Assumptions

1. Mid-to-low elevation forests in the Mokelumne drainage evolved with fire as a key process, but are now at risk of uncharacteristically high severity and stand-replacing wildfire due largely to the following factors:
    - Wildfire is a natural phenomenon in the Sierra Nevada but has been unnaturally suppressed.
    - Lightning strikes are a frequent and a natural source of ignition that will continue into the future.
    - Anthropogenic sources of ignition will likely continue and perhaps increase as the human population grows and recreation and economic activity increases.
    - Some timber management practices over the past 100+ years have inadvertently promoted fire-prone stand conditions.
    - Fire suppression practices over the past 100+ years that have inadvertently promoted fire-prone stand conditions.
    - Climate change is expected to influence future wildfire behavior, although the exact direction of climate change in the Mokelumne River drainage is uncertain. Forecasting models generally agree on future conditions being warmer, but there is uncertainty over whether it will be drier or wetter in the Mokelumne.

2. The probability of ignition for future wildfire is largely determined by:
    - Human sources of ignition are related to road density, campgrounds, and proximity to homes and developed areas.

- Natural ignitions are related to weather and topography.
- The spatial pattern and frequency of historic fire events.
- Fuel moisture levels.
- Fuel types.
- Surface fuel distribution, volume, and structure (e.g. light and airy vs. dense and compacted).
- Forest stand conditions.
- Weather conditions; wind in particular.
- The spatial pattern and frequency of bark beetle/tree mortality events.

3. The spatial area, the spatial pattern, and the severity of future wildfire events is largely determined by:
    - Weather conditions; particularly wind speed and direction, as well as air temperature.
    - Fuel moisture levels.
    - Fuel types.
    - Relative humidity.
    - Eastern wind events.
    - Surface fuel volume and structure (e.g. light and airy vs. dense and compacted).
        - Including fuels associated with bark beetle/tree mortality events.
    - Forest stand conditions.
    - Topography and aspect.
    - Fire suppression feasibility and effectiveness.
    - Spatial distribution of recently burned areas, fuel reduction treatments, fuel breaks, and roads.
    - Fire spotting from lofting burning embers ahead of the fire.

4. Forests in the Mokelumne drainage are highly susceptible to bark beetles and subsequent high levels of tree mortality due largely to the following factors:
    - Management practices over the past 100 years have inadvertently promoted bark beetle-prone stand conditions.
        i. High tree density.
        ii. Age class and species composition differ from historical conditions.
    - High density stands may be more water-stressed.
    - Protracted dry periods are common in the Sierra Nevada.

5. The probability of bark beetle infestations and its corresponding severity and spatial pattern is largely determined by:
    - Stand elevation.
    - Drought conditions (severity and time period).
    - Forest stand conditions.
        i. Species composition.
        ii. Tree size.

iii. Density.
- Spatial distribution of fuel and vegetation management treatments.
- Distance to burned sites.

6. Fuel and vegetation management treatments that change forest stand conditions can change future wildfire behavior and bark beetle infestation levels in terms of spatial area, spatial pattern, and severity. The primary stand level attributes that contribute to fire behavior and susceptibility to bark beetles are:
    - Percent canopy cover affecting surface winds.
    - Height to live crown (or crown base height).
    - Tree species distribution per unit area.
    - Stand density and diversity.
    - Canopy bulk density affecting continuing spread of a crown fire.
    - Vegetation height affecting flame length.
    - The amount of duff, ladder, and surface fuels.

7. The economic cost of fuel and vegetation management treatments on a specific stand can be estimated based on the following attributes:
    - Stem density per unit area.
    - Basal area per unit area.
    - Percent tree canopy cover.
    - Tree species.
    - Tree size class distribution.
    - Type of treatment (e.g. thin from below; thin and masticate; prescribed fire; etc.).
    - Topography, slope, and rockiness.
    - Accessibility in terms of road access.
    - Distance of transport (e.g. to mills, co-generation facilities, sort yards).
    - Prevailing prices for logs and wood chips.
    - Price of diesel fuel.
    - Crew availability and associated costs.
    - Administrative restrictions on operations such as limited operating periods and complexity of treatment prescriptions.

8. Erosion of sediment after wildfire can be much higher than pre-wildfire conditions in forested landscapes. The timing and volume of sediment erosion after wildfire is largely determined by:
    - Wildfire severity, spatial area, and spatial pattern.
    - Soil characteristics.
    - Amount of bare soil after wildfire.
    - Snow and rainfall weather patterns up to 10 years after the wildfire event.
    - Topography.
    - Condition of roads.
    - Probability of landslide and debris flows.

- Condition of meadows and riparian corridors after fire, as a filter to sediment movement.
- Condition of the watershed before fire in relation to recent or historic human impacts from trails, roads, mining, livestock grazing, and timber harvest practices.

9. A net increase in the rate of sediment erosion after wildfire can affect water and electric utilities from the following processes:
    - Sediment may enter water storage facilities such as reservoirs.
    - Sediment may enter or damage water conveyance facilities such as flumes and canals.
    - Sediment may cover/damage out roads and other infrastructure.
    - Sediment may damage hydroelectric turbines and machinery.
    - Sediment may damage water filtration systems.
    - Sediment may cause a decline in water quality for municipal use.
    - Sediment entering the water supply may transport or facilitate mobilization of nitrogen, phosphorous, heavy metals, and other contaminants.

10. The economic costs of sediment erosion can be forecast based upon:
    - Spatial connectivity between wildfire probability, wildfire severity, soil erosion severity, and water storage & conveyance facilities.
    - Forecasts of sediment mobilization and transport from terrestrial sources into stream and river channels.
    - Forecasts of sediment transport through stream and river channels and into water storage and conveyance facilities. Forecasts of costs to dredge reservoirs and clean conveyance facilities.
    - Forecasts of sediment transport from water storage and conveyance facilities and into hydroelectric facilities. Forecasts of costs to change hydroelectric operations or repair/replace machinery and parts.
    - Forecasts of costs associated with facility downtime until a sediment event subsides.
    - Forecasts of sediment transport into water treatment facilities. Increased water treatment costs or costs associated with alternative sources of water or power.

11. Future tree mortality caused by wildfire or bark beetles will result in damage and loss to public and private landowners, in addition to costs associated with erosion of sediment. The economic costs of damage and loss can be forecast based upon spatial overlap between wildfire probability and severity, bark beetle infestation probability and severity, and improvements. Owners and insurers have an important role to play in forecasting the economic costs of damages and losses from wildfire and bark beetles. Categories of ownership include:
    - Government agencies (US Forest Service, Bureau of Land Management, State of California, County): buildings, facilities, campgrounds, signage, equipment, fences, bridges, habitat, and merchantable timber.

- Private small-scale landowners (0-50 acres): homes, barns, buildings, possessions, equipment, livestock, and fences.
- Private medium-scale land owners (51-1,000 acres): homes, barns, buildings, possessions, equipment, livestock, fences, and merchantable timber.
- Private large-scale landowners (>1,000 acres): buildings, facilities, lumber mills, equipment, livestock, fences, bridges, and merchantable timber.
- Water and electric utilities: buildings, facilities, fences, signs, campgrounds, equipment, roads, bridges, electric transmission lines, water conveyance facilities, hydroelectric power facilities, and merchantable timber.

12. Ecosystem services that currently have limited or no defined economic value can be impaired or destroyed by bark beetle infestations and wildfires. These include:
    - Habitat.
    - Air Quality.
    - Water.
    - Meadow function.
    - Aesthetics (e.g. the value people place on living in a beautiful area).
    - Carbon sequestration.

13. Future wildfire and bark beetle outbreaks will have other direct and indirect costs that vary in relation to spatial area, spatial pattern, and severity. Other direct costs include:
    - Fire suppression costs.
    - Bark beetle prevention costs.
    - Hazard tree mitigation costs.
    - Restoration and erosion control costs.
    - Litigation costs.
    - Loss of property value.
    - Replacement of damaged power lines.

14. Salvage logging may be a source of revenue after tree mortality events, based upon:
    - Condition of standing dead timber.
    - Ecological impact of salvage logging.
    - Accessibility of site.

15. The upper Mokelumne drainage covers over 350,000 acres and fuel and vegetation management treatments across the entirety of its forested lands is not possible due to a number of factors, including:
    - Slope.
    - Access.
    - Cost.
    - Endangered species.
    - Wilderness designation.

16. Decisions on where to implement fuel and vegetation management treatments (high-priority areas) will be made based upon an analysis of a number of factors, including:
    - Access.
    - Slope.
    - Vegetation type.
    - Stand health.
    - Erosion potential.
    - Infrastructure and community proximity.
    - Fire probability.
    - Probability of high-intensity fire.
    - Greatest reduction of threat per unit investment.
    - Overlap with goals for later phases of the project.
    - Overlap with other projects.
    - Proximity to cultural resources.
    - Habitat.
    - Matrix of ownership and owners' management goals.

17. Landslides in the Mokelumne watershed may occur due to the following factors:
    - Bare soils.
    - Insufficient root structure.
    - Soil type.
    - Slope.
    - Precipitation type, frequency, and magnitude.
    - Disturbance.
    - Roads.

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Disclaimer

This report is rich in data and analyses and may help support planning processes in the watershed. The data and analyses were primarily funded with public resources and are therefore available for others to use with appropriate referencing of the sources. This analysis is not intended to be a planning document.

The report includes a section on cultural heritage to acknowledge the inherent value of these resources, while also recognizing the difficulty of placing a monetary value on them. This work honors the value of Native American cultural or sacred sites, or disassociated collected or archived artifacts. This work does not intend to cause direct or indirect disturbance to any cultural resources.

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